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Request for grant of a patent

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1/77

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Cardiff Road
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1. Your reference	P34343-/JED/JAL	02JUN03 E811630-1 D02481
2. Patent Application Number *(the Patent Office will fill in this part)*	0312543.2	31 MAY 2003
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	DES Enhanced Recovery Limited Westhill Business Centre Arnhall Business Park Westhill Aberdeen AB32 6US	
Patents ADP number *(if you know it)*	8642258001	
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom	
4. Title of the invention	"Method and Apparatusl"	
5. Name of your agent *(if you have one)*	Murgitroyd & Company	
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	165-169 Scotland Street Glasgow G5 8PL	
Patents ADP number *(if you know it)*	1198015	

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing (day / month / year)

8. Is a statement of inventorship and of right to grant a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	Yes

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Continuation sheets of this form	-
Description	15
Claim(s)	- DL
Abstract	-
Drawing(s)	20+20

10. If you are also filing any of the following, State how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent	-
Request for preliminary examination and search (Patents Form 9/77)	-
Request for substantive examination (Patents Form 10/77)	-
Any other document (please specify)	-

11. I/We request the grant of a patent on the basis of this application

Signature Murgitroyd
MURGITROYD & COMPANY
Date 30/05/2003

12. Name and daytime telephone number of person to contact in the United Kingdom
Jamie Allan 01224 706616

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"Method and Apparatus"

This invention relates to a flow diverter assembly, typically for use at a wellhead of an oil or gas well.

Subsea and topside trees such as christmas trees are well known structures that are employed at the wellhead of an oil or gas well, particularly at the wellhead of an undersea well. The christmas tree comprises an assembly of valves and fluid conduits to control the flow of production fluids from the well, and divert production fluids into export lines for recovery. Our earlier applications WO00/70185 and WO02/38912 relate to existing designs of wellhead and christmas tree, to which external treatment apparatus such as pumps can be attached.

The present application relates to an improvement to this technology, in which a pump is disposed within a conduit of a tree, and typically within a fluid

diverter assembly such as is described in our earlier applications.

In accordance with the invention there is provided a flow diverter assembly for a tree, the flow diverter assembly having a pump adapted to fit within a bore of the tree.

The tree is typically a subsea tree, such as a christmas tree, typically on a subsea well, but a topside tree could also be appropriate. Horizontal or vertical trees are equally suitable for use of the invention.

The flow diverter typically incorporates diverter means to divert fluids flowing through the production bore of the tree from a first portion of the production bore, through the pump, and back to a second portion of the production bore for recovery therefrom via an outlet, which is typically the production wing valve.

The first portion from which the fluids are initially diverted is typically the production bore of the well, and flow from this portion is typically diverted into a diverter conduit sealed within the production bore. Fluid is typically diverted through the bore of the diverter conduit, and after passing therethrough, and exiting the bore of the diverter conduit, typically passes through the annulus created between the diverter conduit and the production bore. At some point on the diverted

fluid path, the fluid passes through the pump internally of the tree, thereby minimising the external profile of the tree, and reducing the chances of damage to the pump.

The pump is typically powered by a motor, and the type of motor can be chosen from several different forms. In some embodiments of the invention, a hydraulic turbine or moineau motor can be driven by any well-known method, for example an electro-hydraulic power pack or similar power source, and can be connected, either directly or indirectly, to the pump. In certain other embodiments, the motor can be an electric motor, powered by a local power source or by a remote power source.

Certain embodiments of the present invention allow the construction of wellhead assemblies that can drive the fluid flow in different directions, simply by reversing the flow of the pump, although in some embodiments valves may need to be changed (e.g. reversed) depending on the design of the embodiment.

The flow diverter assembly typically includes a tree cap that can be retrofitted to existing designs of tree, and can integrally contain the pump and/or the motor to drive it.

The flow diverter preferably also comprises a conduit capable of insertion into the production bore, and may have sealing means capable of sealing the conduit against the wall of the production bore.

The flow diverter typically seals within christmas tree bores above an upper master valve in a conventional tree, or in the tubing hangar of a horizontal tree, and seals can be optionally O-ring, inflatable, elastomeric or metal to metal seals. The cap or other parts of the flow diverter can comprise hydraulic fluid conduits as with our earlier designs of tree cap referred to in the above publications, the contents of which are hereby incorporated by reference. The pump can optionally be sealed within the conduit.

The present invention also provides a method of recovering productions fluids from a well having a tree, the tree having an integral pump located in a bore of the tree, and the method comprising diverting fluids from a first portion of a production bore of the well through the pump and into a second portion of the production bore.

Embodiments of the invention will now be described by way of example, and with reference to the accompanying drawing, in which:-

Fig 1 shows a side view of a first embodiment of a flow diverter assembly;
Fig 2 shows a similar view of a second embodiment;
Fig 3 shows a similar view of a third embodiment;
Fig 4 shows a similar view of a fourth embodiment;

Fig 5 shows a similar view of a fifth embodiment;

Figs 6 and 7 show a sixth embodiment;

Fig 8 and 9 show a seventh embodiment;

Fig 10 and 11 show an eighth embodiment; and

Fig 12 and 13 show a ninth embodiment.

Referring now to the drawings, Fig 1 shows a subsea tree 1 having a production bore 23 for the recovery of production fluids from the well. The tree 1 has a cap body 3 that has a central bore 3b, and which is attached to the tree 1 so that the bore 3b of the cap body 3 is aligned with the production bore 23 of the tree.

Flow of production fluids through the production bore 23 is controlled by the tree master valve 12, which is normally open, and the tree swab valve 14, which is normally closed during the production phase of the well, so as to divert fluids flowing through the production bore 23 and the tree master valve 12, through the production wing valve 13 in the production branch, and to a production line for recovery as is conventional in the art.

In the embodiment of the invention shown in Fig 1, the bore 3b of the cap body 3 contains a turbine or turbine motor 8 mounted on a shaft that is journalled on bearings 22. The shaft extends continuously through the lower part of the cap body bore 3b and into the production bore 23 at which point, a turbine pump, centrifugal pump or, as shown

here a turbine pump 7 is mounted on the same shaft. The turbine pump 7 is housed within a conduit 2.

The turbine motor 8 is configured with inter-collating vanes 8v and 3v on the shaft and side walls of the bore 3b respectively, so that passage of fluid past the vanes in the direction of the arrows 26a and 26b turns the shaft of the turbine motor 8, and thereby turns the vanes of the turbine pump 7, to which it is directly connected.

The bore of the conduit 2 housing the turbine pump 7 is open to the production bore 23 at its lower end, but there is a seal between the outer face of the conduit 2 and the inner face of the production bore 23 at that lower end, between the tree master valve 12 and the production wing branch, so that all production fluid passing through the production bore 23 is diverted into the bore of the conduit 2. The seal is typically an elastomeric or a metal to metal seal.

The upper end of the conduit 2 is sealed in a similar fashion to the inner surface of the cap body bore 3b, at a lower end thereof, but the conduit 2 has apertures 2a allowing fluid communication between the interior of the conduit 2, and the annulus 24, 25 formed between the conduit 2 and the bore of the tree.

The turbine motor 8 is driven by fluid propelled by a hydraulic power pack H which typically flows in

the direction of arrows 26a and 26b so that fluid forced down the bore 3b of the cap turns the vanes 8v of the turbine motor 8 relative to the vanes 3v of the bore, thereby turning the shaft and the turbine pump 7. These actions draw fluid from the production bore 23 up through the inside of the conduit 2 and expels the fluid through the apertures 2a, into the annulus 24, 25 of the production bore. Since the conduit 2 is sealed to the bore above the apertures 2a, and below the production wing branch at the lower end of the conduit 2, the fluid flowing into the annulus 24 is diverted through the annulus 25 and into the production wing through the production wing valve 13 and can be recovered by normal means.

Another benefit of the present embodiment is that the direction of flow of the hydraulic power pack H can be reversed from the configuration shown in Fig 1, and in such case the fluid flow would be in the reverse direction from that shown by the arrows in Fig 1, which would allow the re-injection of fluid from the production wing valve 13, through the annulus 25,24 aperture 2a, conduit 2 and into the production bore 23, all powered by means of the pump 7 and motor 8 operating in reverse. This can allow water injection or injection of other chemicals or substances into all kinds of wells.

In the Fig 1 embodiment, any suitable turbine or moineau motor can be used, and can be powered by any well known method, such as the electro-hydraulic

power pack shown in Fig 1, but this particular source of power is not essential to the invention.

Fig 2 shows a different embodiment that uses an electric motor 4 instead of the turbine motor 8 to rotate the shaft and the turbine pump 7. The electric motor 4 can be powered from an external or a local power source, to which it is connected by cables (not shown) in a conventional manner. The electric motor 4 can be substituted for a hydraulic motor or air motor as required.

Like the Fig 1 embodiment, the direction of rotation of the shaft can be varied by changing the direction of operation of the motor 4, so as to change the direction of flow of the fluid by the arrows in Fig 2 to the reverse direction.

Like the Fig 1 embodiment, the Fig 2 assembly can be retrofitted to existing designs of christmas trees, and can be fitted to many different tree bore diameters. The embodiments described can also be incorporated into new designs of christmas tree as integral features rather than as retrofit assemblies.

Fig 3 shows a further embodiment which illustrates that the connection between the shafts of the motor and the pump can be direct or indirect. In the Fig 3 embodiment, which is otherwise similar to the previous two embodiments described, the electrical motor 4 powers a drive belt 9, which in turn powers

the shaft of the pump 7. This connection between the shafts of the pump and motor permits a more compact design of cap 3. The drive belt 9 illustrates a direct mechanical type of connection, but could be substituted for a chain drive mechanism, or a hydraulic coupling, or any similar indirect connector such as a hydraulic viscous coupling or well known design.

Like the preceding embodiments, the Fig 3 embodiment can be operated in reverse to draw fluids in the opposite direction of the arrows shown, if required to inject fluids such as water, chemicals for treatment, or drill cuttings for disposal into the well.

Fig 4 shows a further modified embodiment using a hollow turbine shaft 2s that draws fluid from the production bore 23 through the inside of conduit 2 and into the inlet of a combined motor and pump unit 5,7. The motor/pump unit has a hollow shaft design, where the pump rotor 7r is arranged concentrically inside the motor rotor 5r, both of which are arranged inside a motor stator 5s. The pump rotor 7r and the motor rotor 5r rotate as a single piece on bearings 22 around the static hollow shaft 2s thereby drawing fluid from the inside of the shaft 2 through the upper apertures 2u, and down through the annulus 24 between the shaft 2s and the bore 3b of the cap 3. The lower portion of the shaft 2s is apertured at 21, and the outer surface of the conduit 2 is sealed within the bore of the shaft 2s

above the lower aperture 21, so that fluid pumped from the annulus 24 and entering the apertures 21, continues flowing through the annulus 25 between the conduit 2 and the shaft 2s into the production bore 23, and finally through the production wing valve 13 for export as normal.

The motor can be any prime mover of hollow shaft construction, but electric or hydraulic motors can function adequately in this embodiment. The pump design can be of any suitable type, but a moineau motor, or a turbine as shown here, are both suitable.

Like previous embodiments, the direction of flow of fluid through the pump shown in Fig 4 can be reversed simply by reversing the direction of the motor, so as to drive the fluid in the opposite direction of the arrows shown in Fig 4.

Referring now to Fig 5a, this embodiment employs a motor 6 in the form of a disc rotor that is preferably electrically powered, but could be hydraulic or could derive power from any other suitable source, connected to a centrifugal disc-shaped pump 7 that draws fluid from the production bore 23 through the inner bore of the conduit 2 and uses centrifugal impellers to expel the fluid radially outwards into collecting conduits 24, and thence into an annulus 25 formed between the conduit 2 and the production bore 23 in which it is sealed. As previously described in earlier embodiments, the

fluid propelled down the annulus 25 cannot pass the seal at the lower end of the conduit 2 below the production wing branch, and exits through the production wing valve 13.

Fig 5b shows the same pump configured to operate in reverse, to draw fluids through the production wing valve 13, into the conduit 25, across the pump 7, through the re-routed conduit 24′ and conduit 2, and into the production bore 23.

One advantage of the Fig 5 design is that the disc shaped motor and pump illustrated therein can be duplicated to provide a multi-stage pump with several pump units connected in series and/or in parallel in order to increase the pressure at which the fluid is pumped through the production wing valve 13.

Referring now to Figs 6 and 7, this embodiment illustrates a piston 15 that is sealed within the bore 3b of the cap 3, and connected via a rod to a further lower piston assembly 16 within the bore of the conduit 2. The conduit 2 is again sealed within the bore 3b and the production bore 23. The lower end of the piston assembly 16 has a check valve 19.

The piston 15 is moved up from the lower position shown in Fig 6a by pumping fluid into the aperture 26a through the wall of the bore 3b by means of a hydraulic power pack in the direction shown by the arrows in Fig 6a. The piston annulus is sealed

below the aperture 26a, and so a build-up of pressure below the piston pushes it upward towards the aperture 26b, from which fluid is drawn by the hydraulic power pack. As the piston 15 travels upward, a hydraulic signal 30 is generated that controls the valve 17, to maintain the direction of the fluid flow shown in Fig 6a. When the piston 15 reaches it's uppermost stroke, another signal 31 is generated that switches the valve 17 and reverses direction of fluid from the hydraulic power pack, so that it enters through upper aperture 26b, and is exhausted through lower aperture 26a, as shown in Fig 7a. Any other similar switching system could be used, and fluid lines are not essential to the invention.

As the piston is moving up as shown in Fig 6a, production fluids in the production bore 23 are drawn into the bore 2b of the conduit 2, thereby filling the bore 2b of the conduit underneath the piston. When the piston reaches the upper extent of its travel, and begins to move downwards, the check valve 19 opens when the pressure moving the piston downwards exceeds the reservoir pressure in the production bore 23, so that the production fluids 23 in the bore 2b of the conduit 2 flow through the check valve 19, and into the annulus 24 between the conduit 2 and the piston shaft. Once the piston reaches the lower extent of its stroke, and the pressure between the annulus 24 and the production bore 23 equalises, the check valve 19 in the lower piston assembly 16 closes, trapping the fluid in the

annulus 24 above the lower piston assembly 16. At that point, the valve 17 switches, causing the piston 15 to rise again and pull the lower piston assembly 16 with it. This lifts the column of fluid in the annulus 24 above the lower piston assembly 16, and once sufficient pressure is generated in the fluid in the annulus 24 above lower piston assembly 16, the check valves 20 at the upper end of the annulus open, thereby allowing the well fluid in the annulus to flow through the check valves 20 into the annulus 25, and thereby exhausting through wing valve 13 branch conduit. When the piston reaches its highest point, the upper hydraulic signal 31 is triggered, changing the direction of valve 17, and causing the pistons 15 and 16 to move down their respective cylinders. As the piston 16 moves down once more, the check valve 19 opens to allow well fluid to fill the displaced volume above the moving lower piston assembly 16, and the cycle repeats.

The fluid driven by the hydraulic power pack can be driven by other means. Alternatively, linear oscillating motion can be imparted to the lower piston assembly 16 by other well-known methods i.e. rotating crank and connecting rod, scotch yolk mechanisms etc.

By reversing and/or re-arranging the orientations of the check valves 19 and 20, the direction of flow in this embodiment can also be reversed, as shown in Fig 6d.

The check valves shown are ball valves, but can be substituted for any other known fluid valve. The Figs 6 and 7 embodiment can be retrofitted to existing trees of varying diameters or incorporated into the design of new trees.

Referring now to Figs 8 and 9, a further embodiment has a similar piston arrangement as the embodiment shown in Figs 6 and 7, but the piston assembly 15,16 is housed within a cylinder formed entirely by the bore 3b of the cap 3. As before, drive fluid is pumped by the hydraulic power pack into the chamber below the upper piston 15, causing it to rise as shown in Fig 8a, and the signal line 30 keeps the valve 17 in the correct position as the piston 15 is rising. This draws well fluid through the conduit 2 and check valve 19 into the chamber formed in the cap bore 3b. When the piston has reached it's full stroke, the signal line 31 is triggered to switch the valve 17 to the position shown in Fig 9a, so that drive fluid is pumped in the other direction and the piston 15 is pushed down. This drives piston 16 down the bore 3b expelling well fluid through the check valves 20 (valve 19 is closed), into annulus 24, 25 and through the production wing valve 13. In this embodiment the check valve 19 is located in the conduit 2, but could be immediately above it. By reversing the orientation of the check valves as in previous embodiments the flow of the fluid can be reversed.

A further embodiment is shown in Figs 10 and 11, which works in a similar fashion but has a short diverter assembly 2 sealed to the production bore and straddling the production wing branch. The lower piston 16 strokes in the production bore 23 above the diverter assembly 2. As before, the drive fluid raises the piston 15 in a first phase shown in fig 10, drawing well fluid through the check valve 19, through the diverter assembly 2 and into the upper portion of the production bore 23. When the valve 17 switches to the configuration shown in Fig 11, the pistons 15, 16 are driven down, thereby expelling the well fluids trapped in the bore 23u, through the check valve 20 (valve 19 is closed) and the production wing valve 13.

Fig 12 shows a further embodiment, which employs a rotating crank 10 with an eccentrically attached arm 10a instead of a fluid drive mechanism to move the piston 16. The crank 10 is pulling the piston upward when in the position shown in Fig 12a, and pushing it downward when in the position shown in 12b. This draws fluid into the upper part of the production bore 23u as previously described. The straddle 2 and check valve arrangements as described in the previous embodiment.

Modifications and improvements can be incorporated without departing from the scope of the invention.

Fig. 1

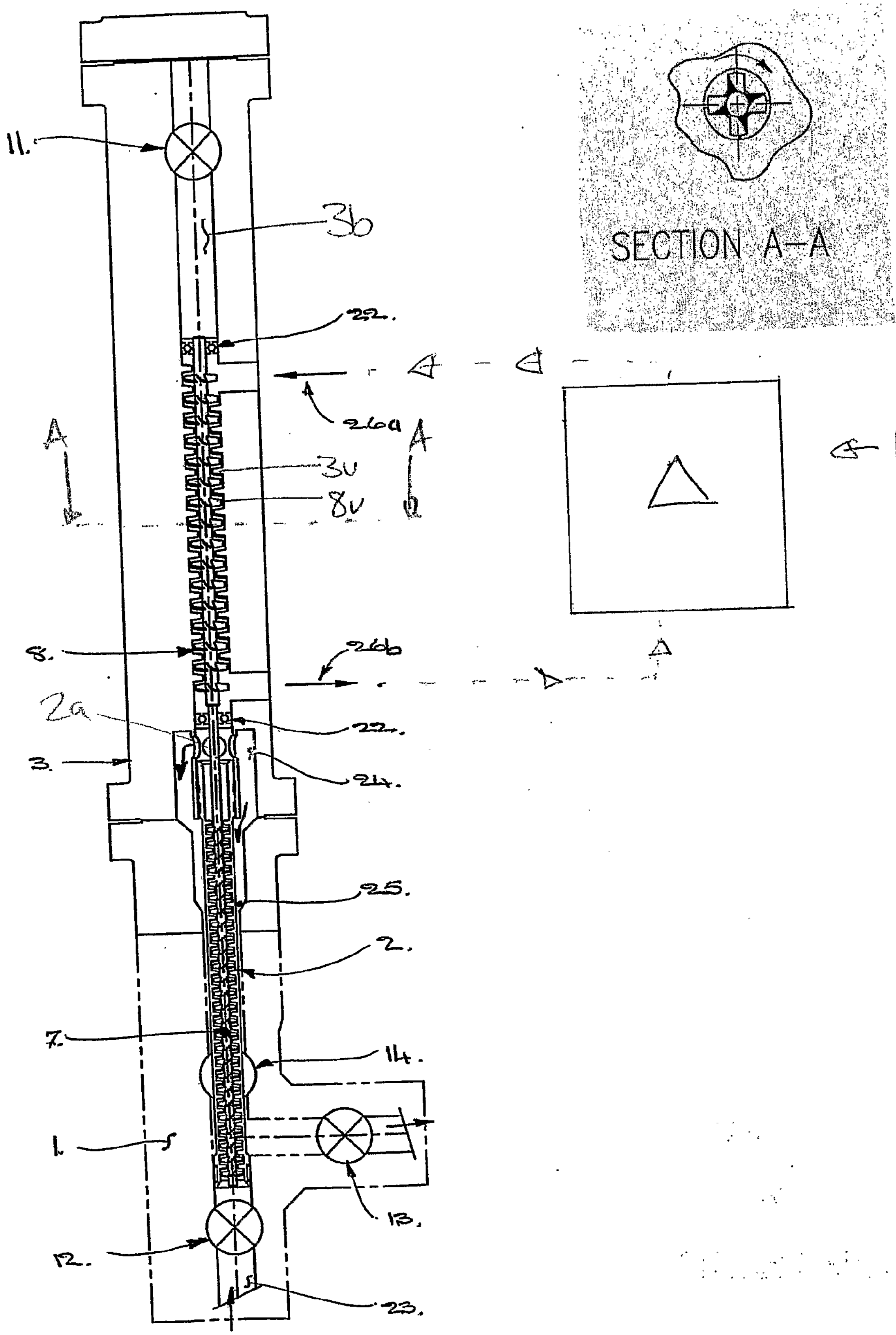


Fig. 2

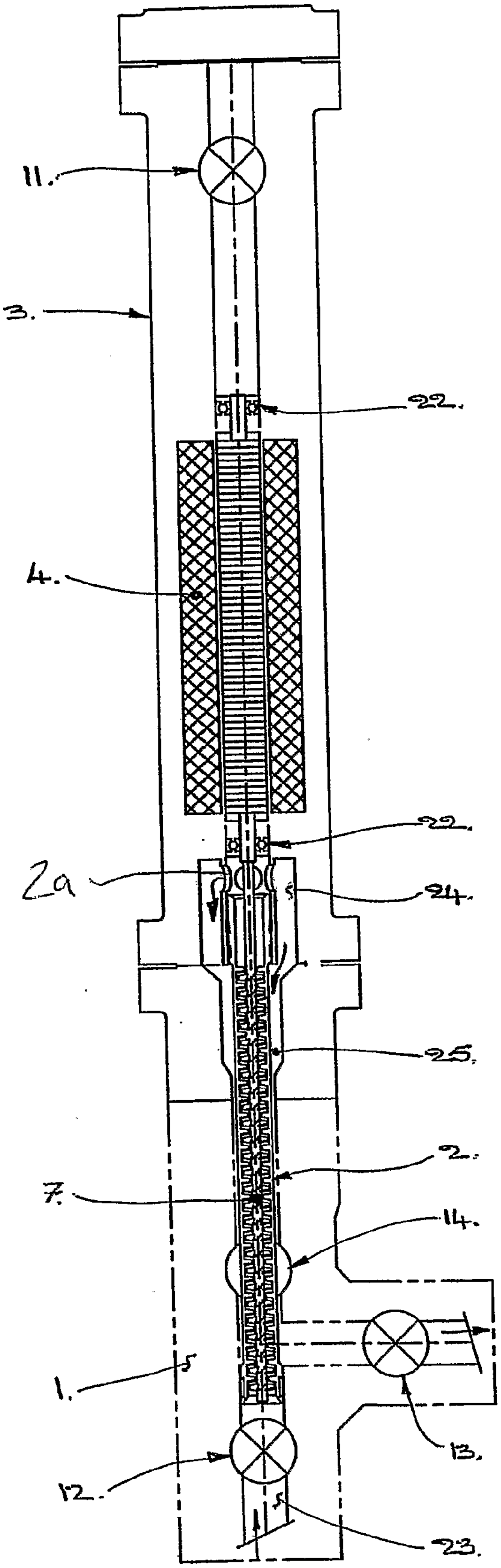


Fig. 3

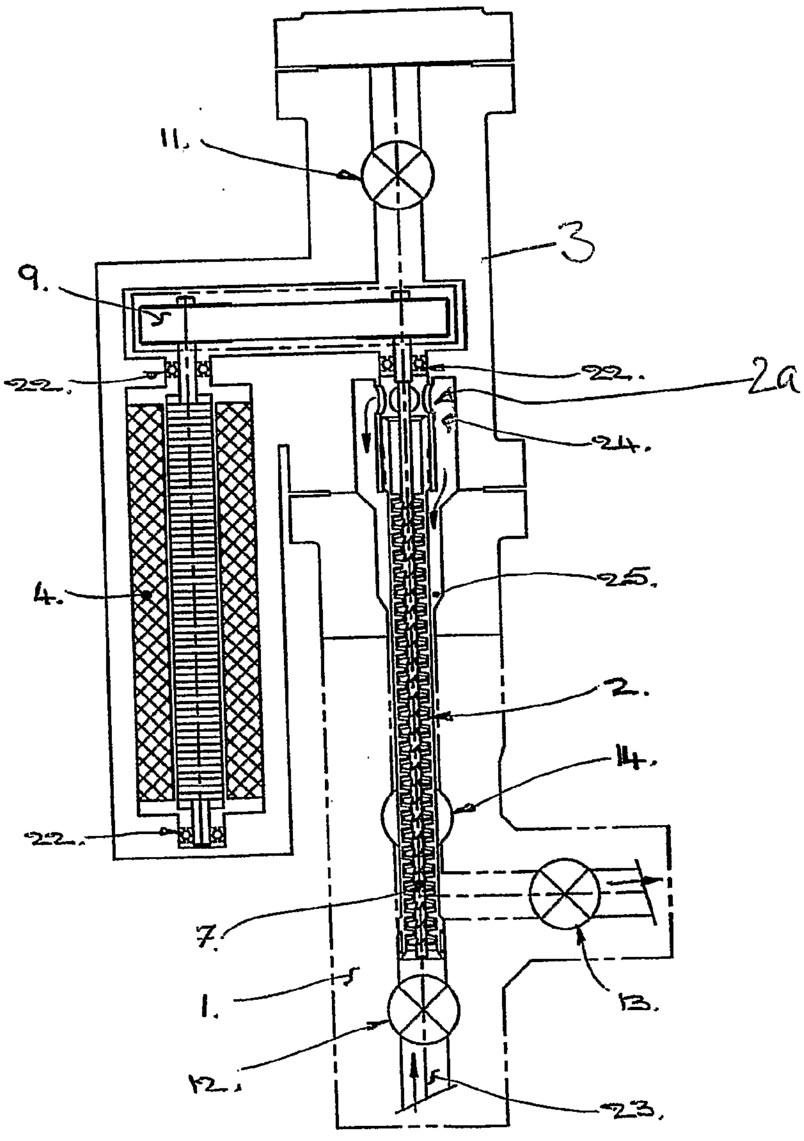
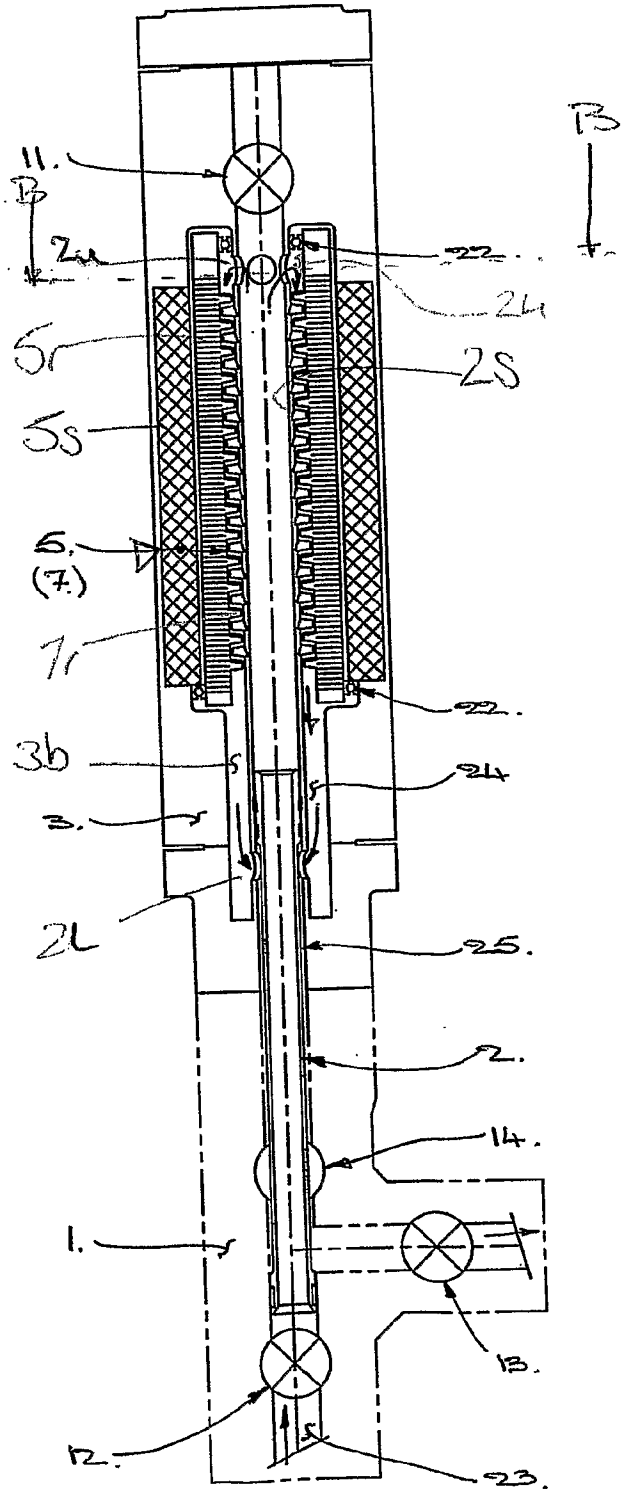
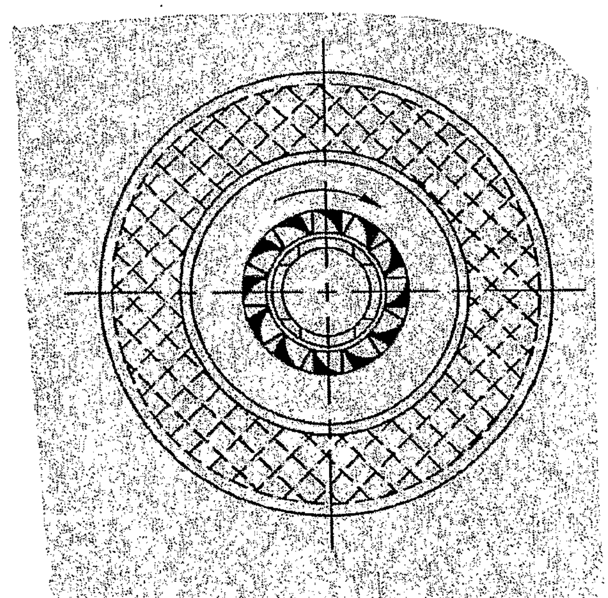


Fig. 4





SECTION B-B

Fig. 5a

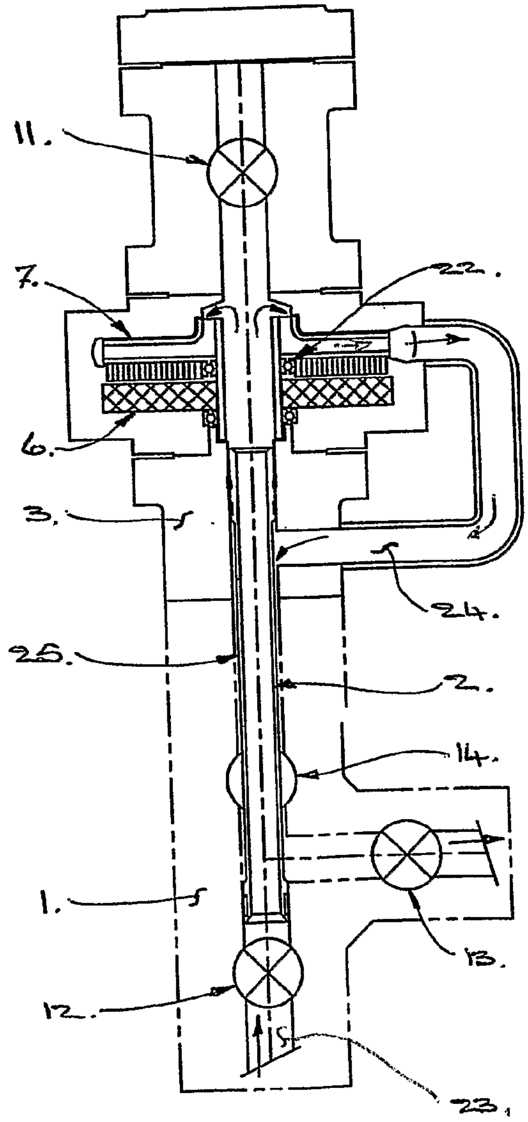


Fig. 5b

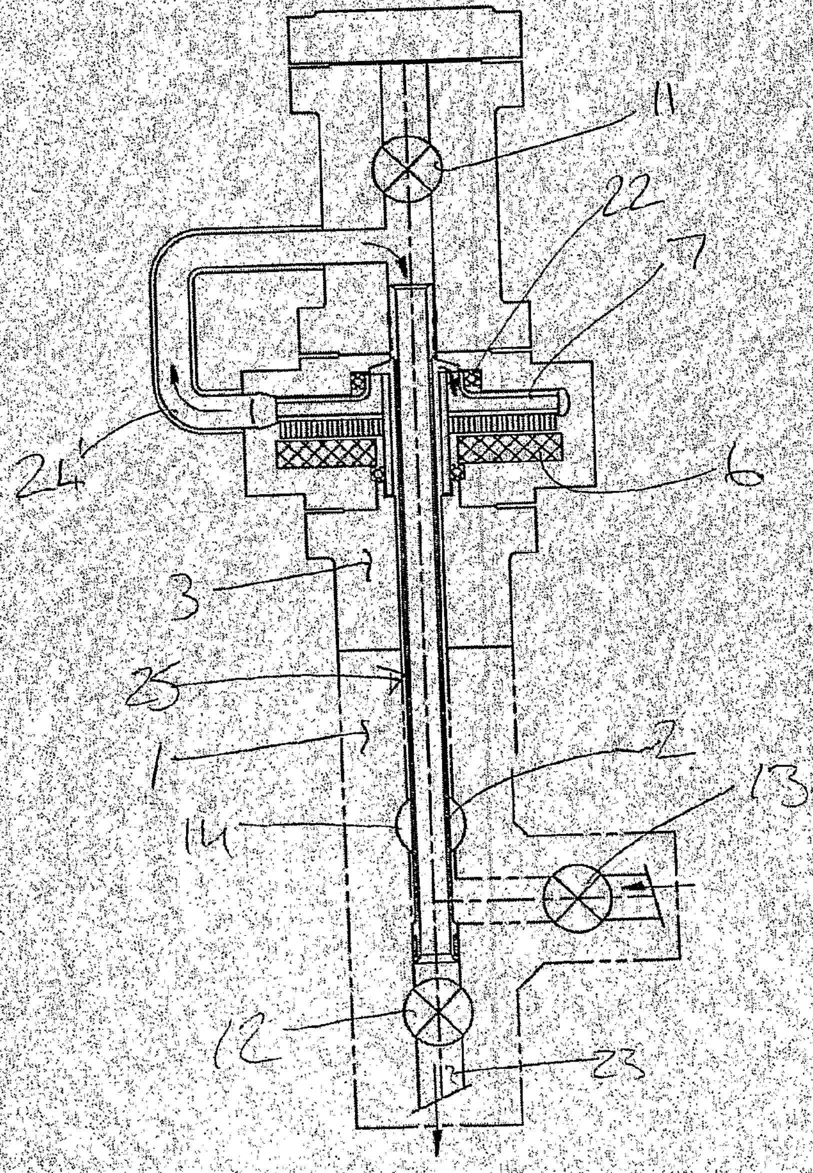
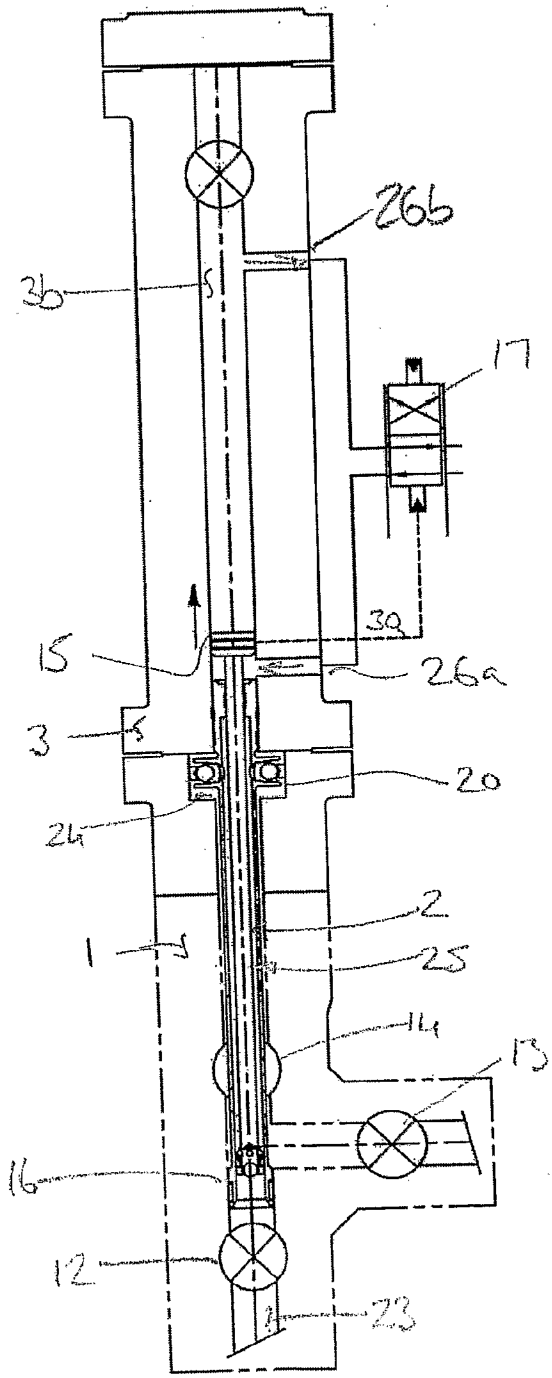


Fig. 6a



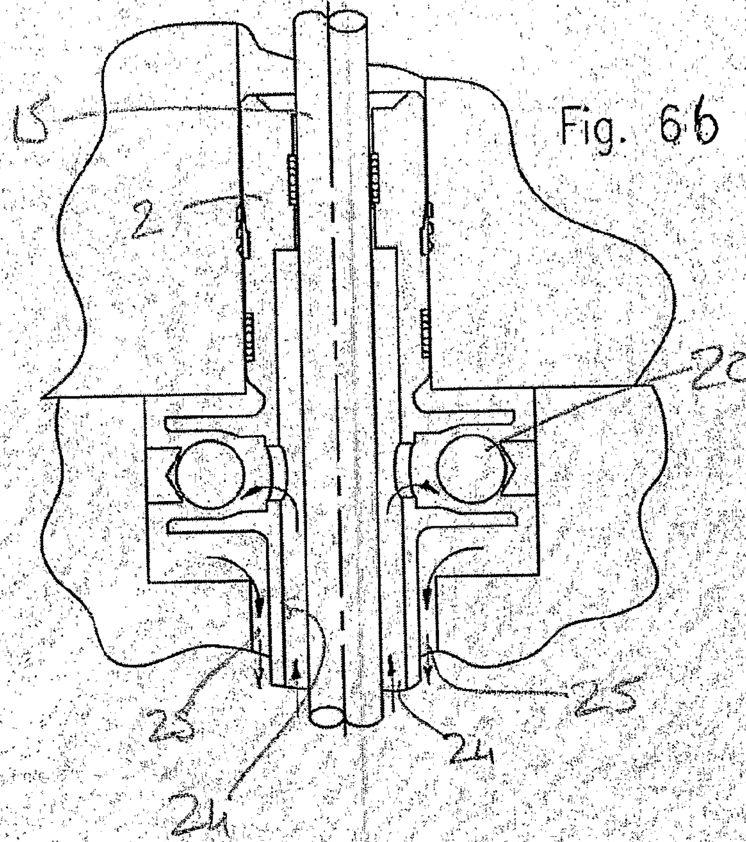


Fig. 6b

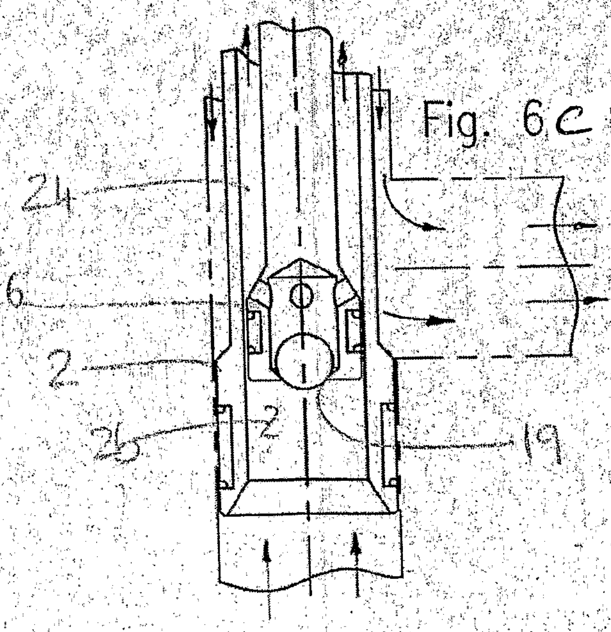


Fig. 6c

Fig. 6d

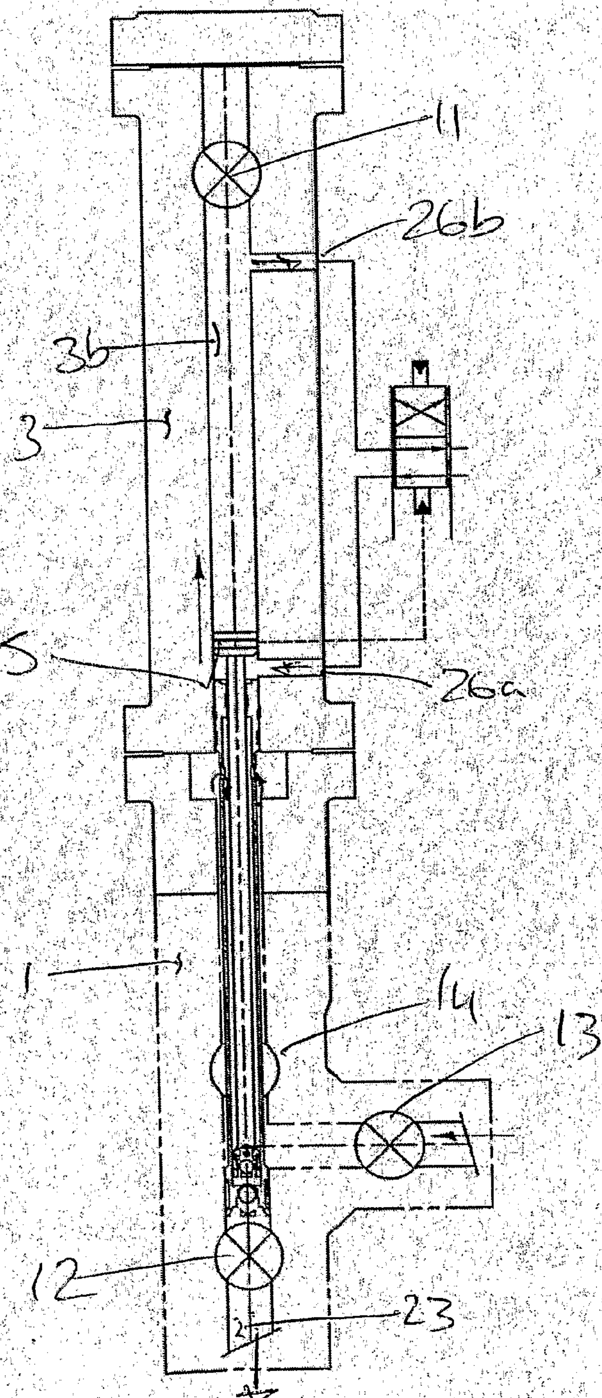


Fig. 7a

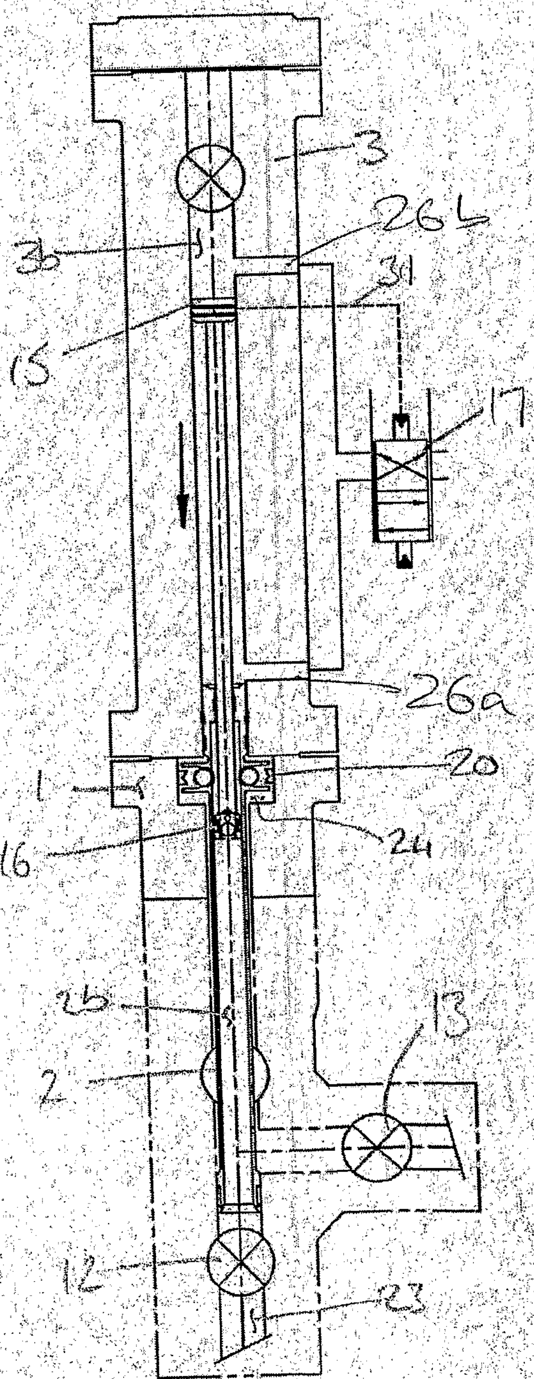


Fig. 7b

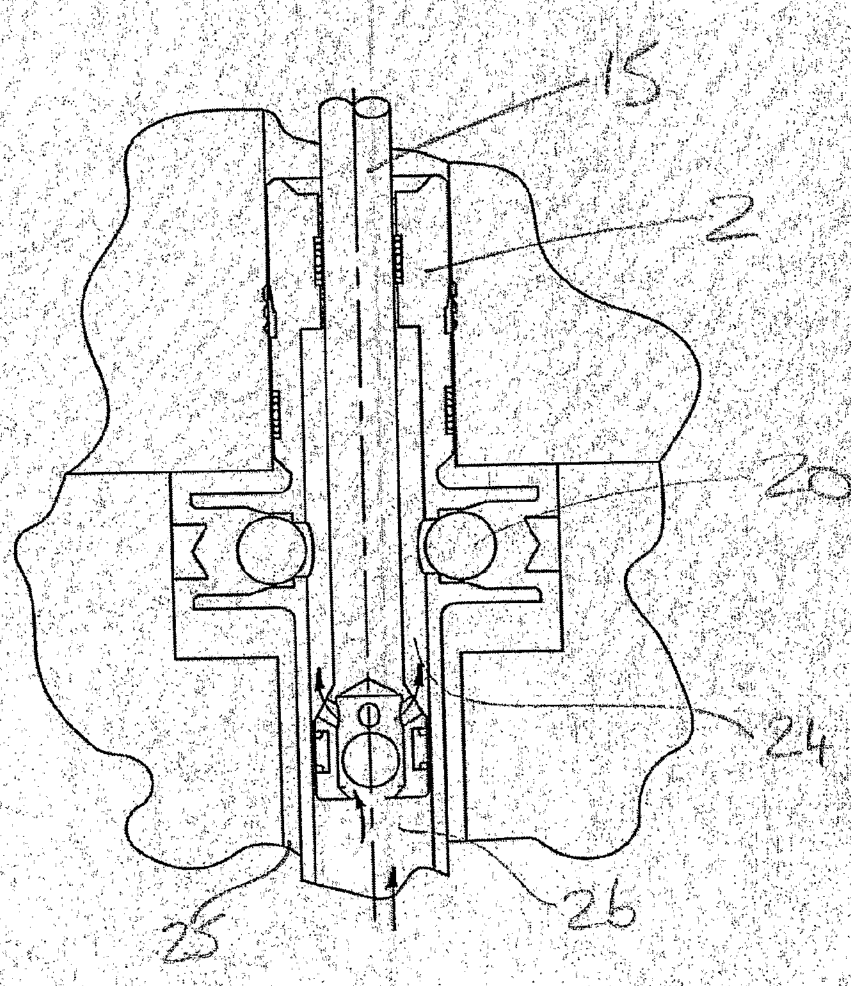


Fig.8a

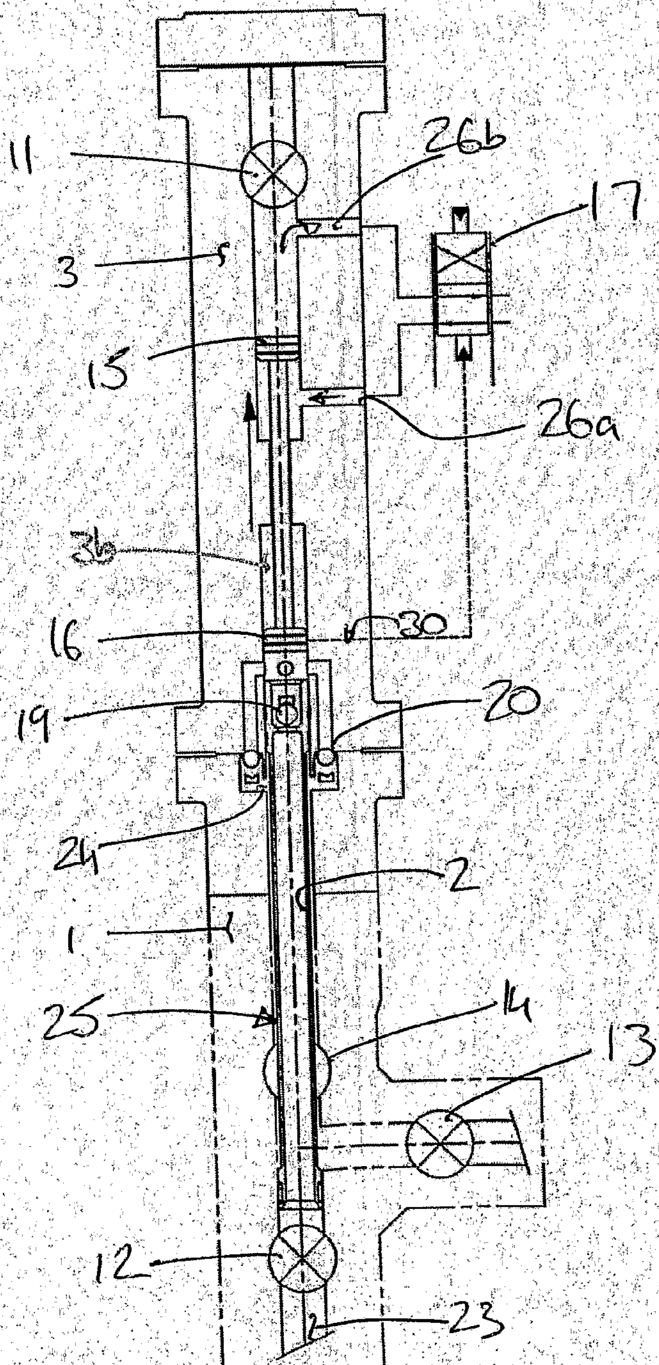


Fig. 8 b

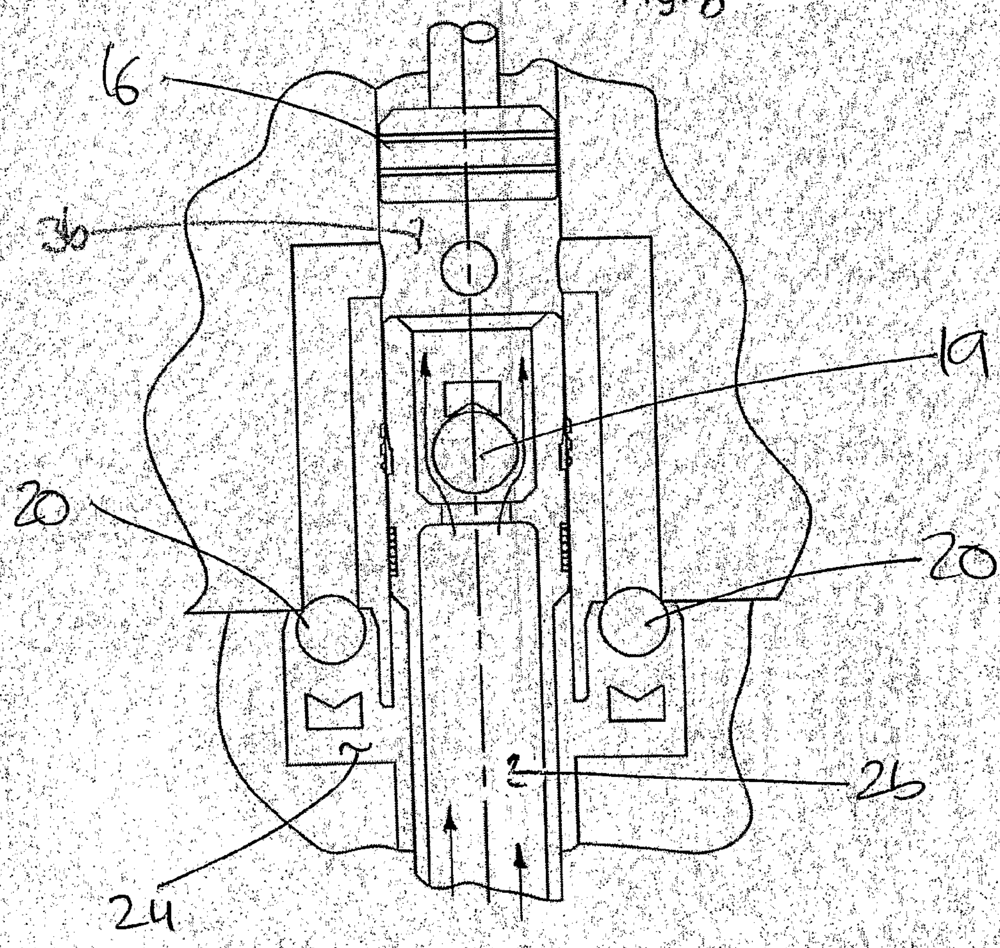


Fig. 9a

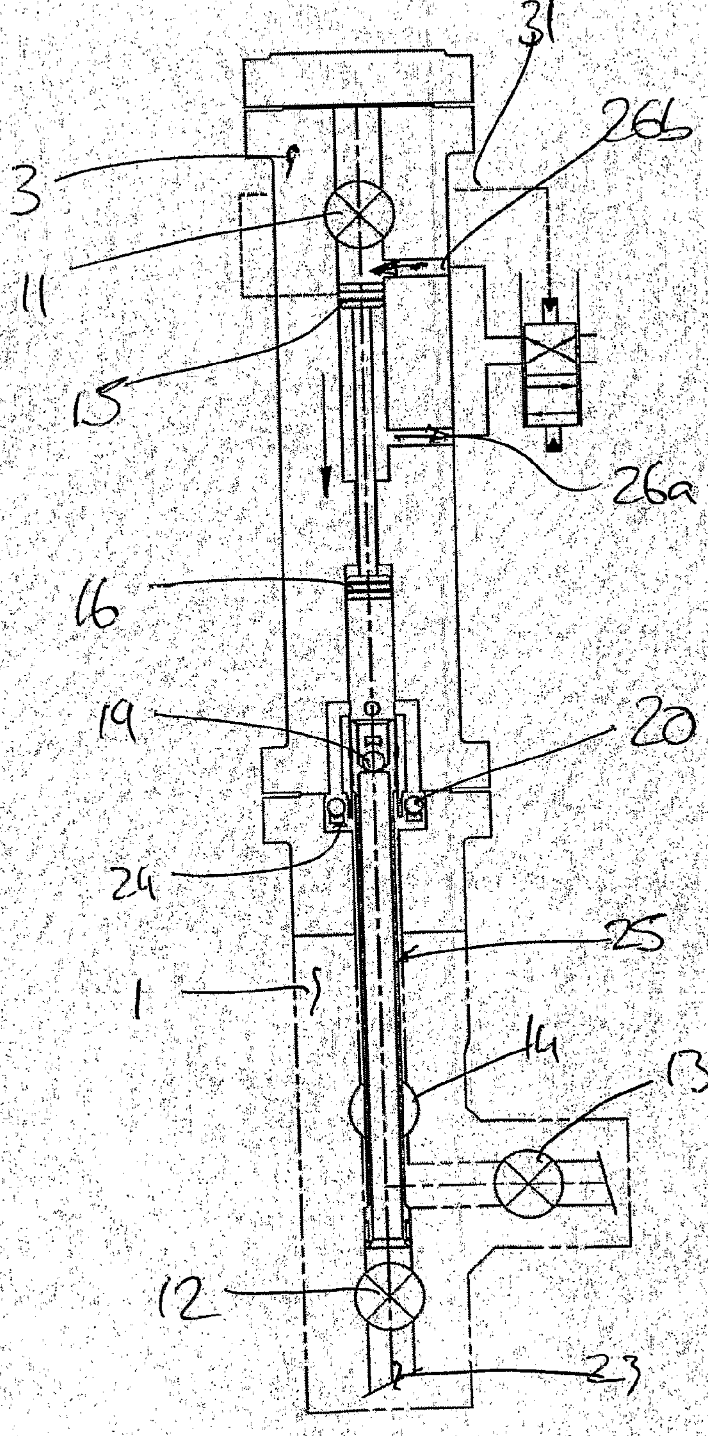


Fig. 9b

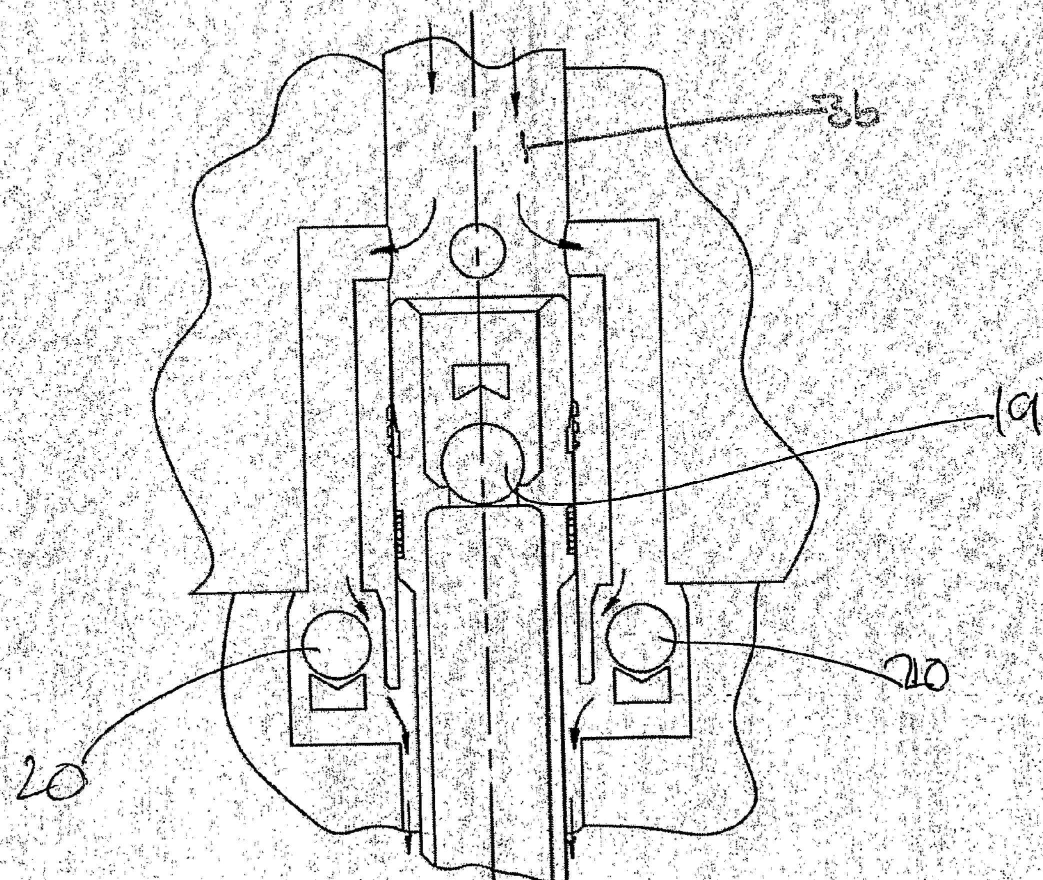
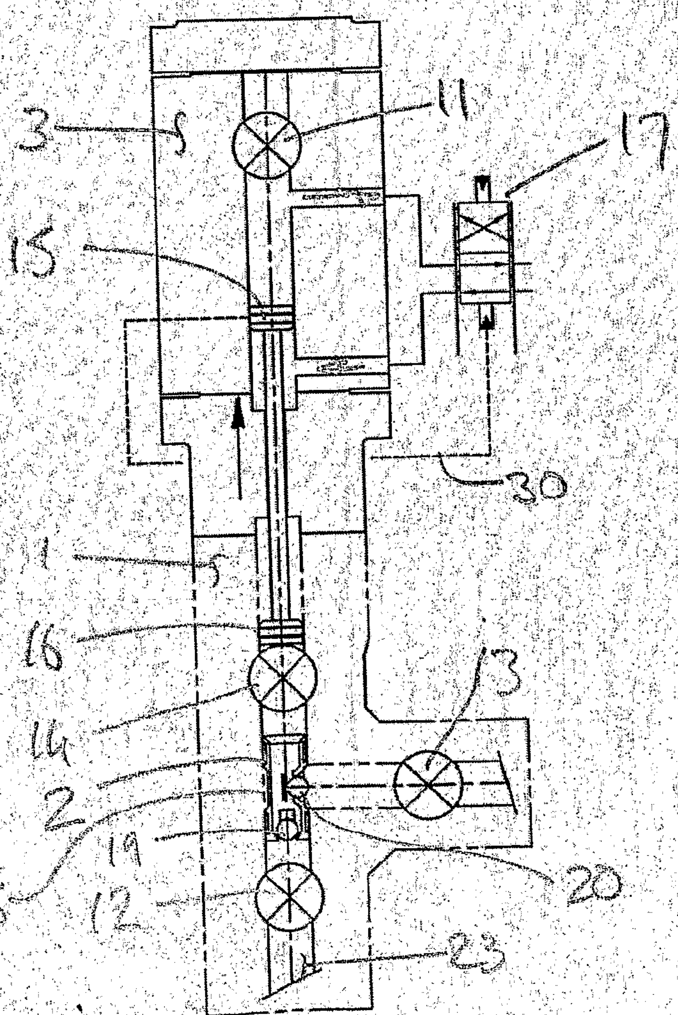


Fig. 10a



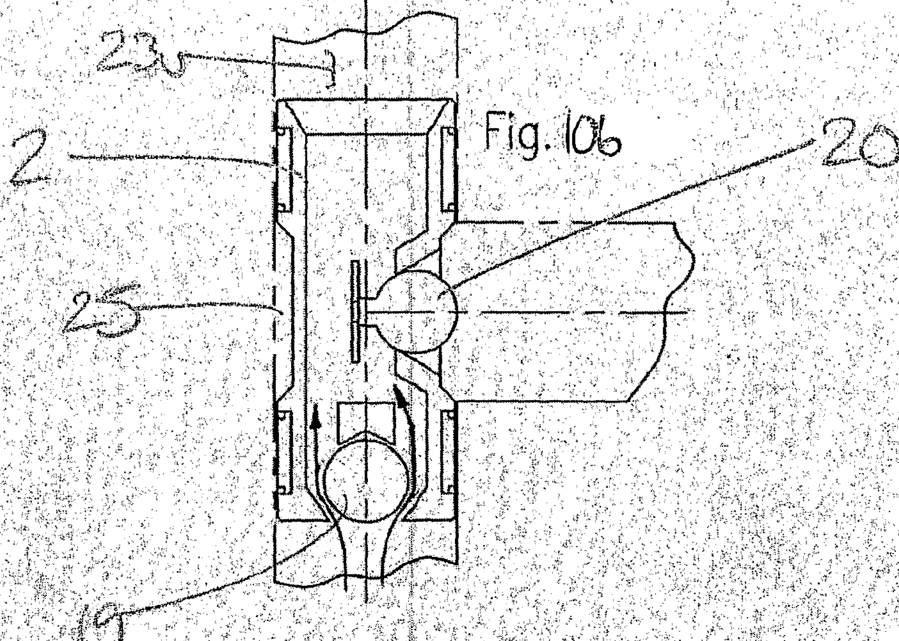


Fig. 10b

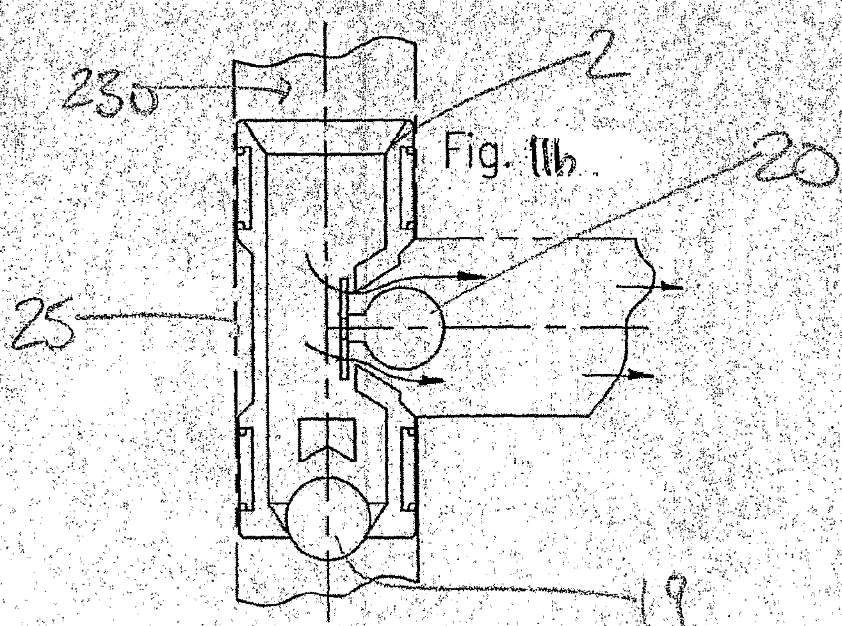


Fig. 11b

Fig. 11a

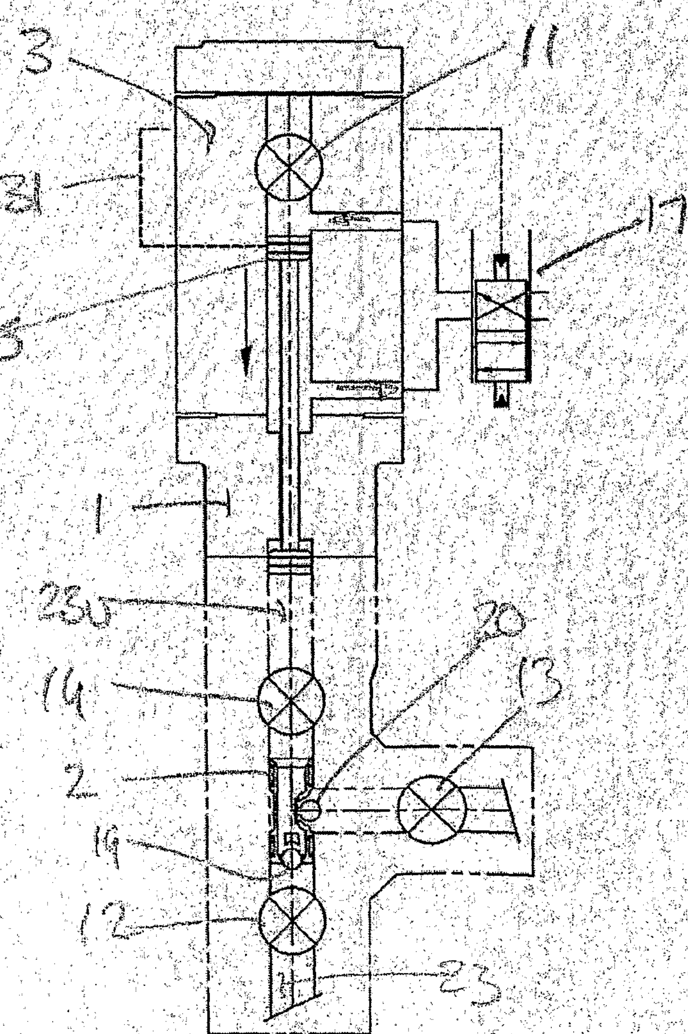


Fig. 12a

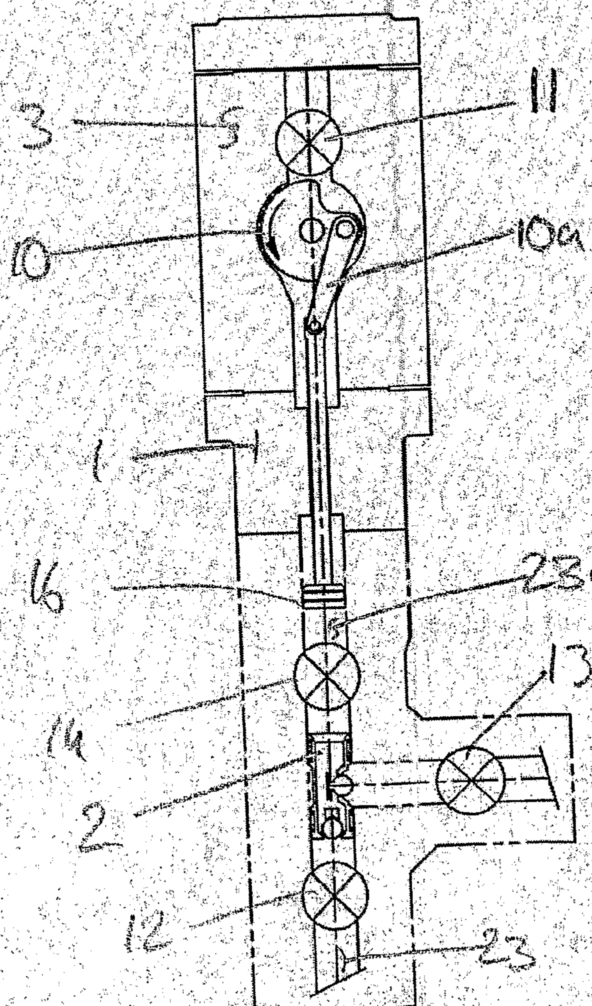
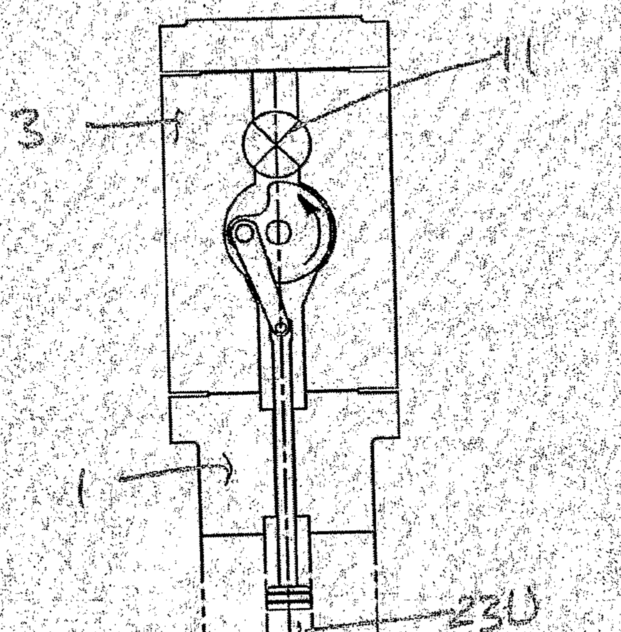


Fig. 12b



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